Final Report
Roadway Pavement Grinding Noise Study

I-215 Salt Lake City

Prepared for

Utah Department of Transportation

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1.0 INTRODUCTION

Texturing of roadway pavement surfaces is necessary to provide adequate resistance to skidding, and to allow water to escape from under tires to minimize hydroplaning. This texturing, however, has been shown to contribute to tire noise on rigid pavements. Large aggregate mixes have also been shown to increase tire noise. Studies have been conducted by other agencies to evaluate which textures provide the needed safety attributes, while reducing the noise levels or the pure tone frequencies or “whine” that are annoying to the public. Other pavement deficiencies have been shown to contribute to tire noise as well. Joint faulting and other pavement roughness can create increases in pavement noise due to tire slap.

The purpose of this experimental project is to grind a new texture into I-215 and monitor its performance. This report presents the results of the noise levels that were measured before grinding, after grinding a 300 foot section and again after grinding all of I-215. The results of similar studies performed in other states and in Europe have been provided in a previous report dated November 2000 for comparative purposes.

2.0 PAVEMENT TEST SECTION

The test section is located on the east leg of I-215 at approximately 5000 South (M.P. 4.6) on both the northbound and southbound lanes. The surface texturing was performed by diamond grinding the plane-jointed concrete pavement built in 1990. The general condition of the pavement is considered to be good with respect to ride quality, with IRI values in inches per mile of 100 northbound lane (NBL) and 93 southbound lane (SBL). The faulting of the joints is considered minor, with more than 90% of the faults less than 0.1 inch in depth.

The original tining placed during construction was raked into the plastic concrete in the transverse direction. The tining was 1/8 inch wide, 1/16 inch deep, and spaced 1/2 inch apart. After 10 years of traffic, the tining has been worn down to some degree. Enough of the tining still exists in the wheel-paths to contribute to tire whine.

The diamond grinding gave the surface a longitudinal oriented texture that was about 1/16 inch in depth at the time of construction.

3.0 NOISE MEASUREMENTS

The pre-grinding measurements were conducted on May 9, 2000 at five locations along the northbound lanes of I-215 in Salt Lake City (Figure 1). All measurements were taken during free flow traffic after the AM peak hour. Noise data was recorded for 15-minutes periods at each measurement site and digitally stored on a Larson Davison 2900 two-channel real time sound analyzer.

Site A – At the edge of pavement of the northbound lanes (25 feet from the traveled way), 150 feet from the start of the 300-foot grind area.

Site B – At the edge of pavement of the northbound lanes (25 feet from the traveled way), 200 feet south of channel one, about 50 feet before the grind area. Noise levels at Sites A and B was recorded simultaneously.

Site C – Relocated the microphone from Site A to 25 feet back from edge of pavement of the northbound lanes (50 feet from the traveled way), 150 feet from the start of the 300-foot grind area.

Site D – Relocated the microphone from Site B to 25 feet back for edge of pavement of the northbound lanes (50 feet from the traveled way), 200 feet south of channel one, about 50 feet before the grind area. Noise levels at Sites C and D were recorded simultaneously.

Site E –150 feet from the start of the grind area and 75 feet behind Site C, about 100 feet form the edge of pavement of the northbound lanes. Noise levels at Sites C and E were recorded simultaneously.

The post grinding noise measurements were conducted on May 31, 2000 at the same locations with the exception of the following additional measurement site that was included at the request of UDOT to measure traffic noise levels from the southbound lanes of I-215.

Site F – At the edge of pavement of the southbound lanes, 150 feet from the start of the grind area.

Site G – 25 feet from the edge of pavement of the southbound lanes, 150 feet from the start of the grind area.

Noise measurements were conducted again on May 21, 2003, after a larger section of the I-215 was ground. Measurements were conducted at the same locations, except Sites B and D, which were now inside the grind area of pavement and not needed as control sites.

3.1 Results of Measured Noise Data

The measured noise levels were analyzed in 1/3 octave sound pressure levels and are presented in Figures 2 through 6 for the following conditions:

- Figure 2 – The sound pressure level data at Site A, the edge of shoulder of the northbound lanes, represents the closest microphone location to the traffic. This data compares the measurements made on different days during the same time period before and after grinding at the same measurement location.
- Figure 3 – The sound pressure level data at Site C, 25 feet from the edge of shoulder of the northbound lanes, compares the measurements made on different days during the same time period before and after grinding at the same measurement location.

- Figure 4 – The sound pressure level data at Site E, 25 feet from the edge of shoulder of the northbound lanes, compares the measurements made on different days during the same time period before and after grinding at the same measurement location.
- Figure 5 – The sound pressure level data presented represents simultaneous noise measurements taken of the same traffic at Site A, edge of shoulder, next to the pavement area that was ground and Site B, next to the original pavement surface that is directly south of the ground pavement.
- Figure 6 – The sound pressure level data presented represents simultaneous noise measurements taken of the same traffic at Site C, 25 feet from edge of shoulder, next to the pavement area that was ground and Site D, next to the original pavement surface that is directly south of the ground pavement.

The A-scale (dBA) measured noise levels are summarized in Table 1. Data for Sites F and G, requested by UDOT during the post grinding measurements, do not represent the change in traffic noise levels due to the grinding.

3.2 Data Analysis

The noise reduction from the pavement grinding is highest, 5.0 dBA at Site A, where the microphone location was closest to the traveled lanes. As the measurement location is moved further from the travel lanes the reduction is less, 2.6 dBA at Site C and 0.2 dBA at Site E. The measured data indicates that the noise contribution from the tire pavement interaction is more predominate at closer distances to the traffic. This effect is lessened at larger distances where the contribution of truck exhaust stack noise is more prevalent. Table 1 shows the reduction from pavement grinding from the 2000 noise measurements. Table 2 show the reduction in noise levels between the 2000 pre-grinding and the 2003 post grinding noise measurements. The changes in post grinding noise levels between 2000 and 2003 are presented in Table. The other variable in these measured data is the traffic volumes, speed and vehicle mix. The 0.6 to 2.0 dBA reduction in noise levels between 2000 and 2003 is primarily due to the change in the traffic volumes with the additional grinding having a lesser effect. The traffic counts on northbound I-215 taken during the noise measurements are presented in Table 4.

The comparison of the simultaneous measurements at Sites A – C, and Sites B – D indicate lower noise reductions than the data taken at these same sites during different days.

Table 1
Summary of 2000 Noise Measurements

Measurement Sites	Microphone Location	Pre-Grinding Noise Levels (dBA)	Post Grinding Noise Levels (dBA)	Noise Reduction due to Pavement Grinding
Site A	Edge of Shoulder	84.2	79.2	5.0
Site C	25 feet from Edge of Shoulder	81.2	78.6	2.6
Site E	125 feet from Edge of Shoulder	76.4	76.2	0.2
Site F	Edge of Shoulder - Southbound Lanes	----	79.0	N/A
Site G	25 feet from Edge of Shoulder - Southbound Lanes	----	77.9	N/A

Simultaneous Measurement Sites	Microphone Location	Outside of Grind Area	Within Grind Area	Noise Reduction due to Pavement Grinding
Sites A & B	Edge of Shoulder	81.5 (Site B)	79.2 (Site A)	2.3
Sites C & D	25 feet from Edge of Shoulder	79.6 (Site D)	78.6 (Site C)	1.0

Table 2
Comparison of 2000 Pre-Grinding & 2003 Post Grinding Noise Measurements

Measurement Sites	Microphone Location	Pre-Grinding 2000 Noise Levels (dBA)	Post Grinding 2003 Noise Levels (dBA)	Difference in Noise Levels Due to Grinding
Site A	Edge of Shoulder	84.2	78.6	5.6
Site C	25 feet from Edge of Shoulder	81.2	76.6	4.6
Site E	125 feet from Edge of Shoulder	76.4	74.3	2.1

Table 3
Comparison of 2000 & 2003 Post Grinding Noise Measurements

Measurement Sites	Microphone Location	Post Grinding 2000 Noise Levels (dBA)	Post Grinding 2003 Noise Levels (dBA)	Difference in Noise Levels due to Changes in Traffic And additional grinding
Site A	Edge of Shoulder	79.2	78.6	0.6
Site C	25 feet from Edge of Shoulder	78.6	76.6	2.0
Site E	125 feet from Edge of Shoulder	76.2	74.3	1.9
Site F	Edge of Shoulder - Southbound Lanes	79.1	77.8	N/A
Site G	25 feet from Edge of Shoulder - Southbound Lanes	77.9	76.3	N/A

Table 4
Traffic Counts – Northbound I-215

		15 Minute Count				1 Hour Volume				Vehicle Percent		
		Total	Cars	MT	HT	Total	Cars	MT	HT	Cars	MT	HT
Site A	Pre-Grinding 2000	662	628	19	15	2648	2512	76	60	95%	3%	2%
Site A	Post Grinding 2000	664	607	33	24	2656	2428	132	96	91%	5%	4%
Site A	Post Grinding 2003	593	555	26	12	2372	2220	104	48	94%	4%	2%
Site C	Pre-Grinding 2000	614	571	26	17	2456	2284	104	68	93%	4%	3%
Site C	Post Grinding 2000	591	538	27	26	2364	2152	108	104	91%	5%	4%
Site C	Post Grinding 2003	556	510	29	17	2224	2040	116	68	92%	5%	3%
Site E	Pre-Grinding 2000	562	524	24	14	2248	2096	96	56	93%	4%	2%
Site E	Post Grinding 2000	540	488	19	33	2160	1952	76	132	90%	4%	6%
Site E	Post Grinding 2003	518	481	12	15	2072	1964	48	60	95%	2%	3%

3.3 Summary and Conclusions

Since traffic noise consists of pavement/tire noise and vehicle engine exhaust noise, the benefits of the pavement grinding is reduced by the noise contribution from heavy truck engine stack noise. At speeds of approximately 60 mph or less, the engine stack noise of a heavy truck is higher than the tire noise. At lower speeds, the gap in this relationship widens, where the engine stack exhaust noise is the predominate source of truck noise. The maximum noise reduction of the pavement grinding was measured at the edge of shoulder and decreased as the distance from the traffic increased. At the near field to the tire/pavement noise, the lower frequency truck engine stack exhaust noise, which is at a source height in the range of 8 to 12 feet above the pavement surface, will diffract over the 5-foot high microphone location. As the distance between the microphone and the traffic increases, the truck engine stack noise becomes more significant.

The potential traffic noise reduction of the pavement grinding to the communities along I-215 would be in the range of 1 dBA to 2 dBA depending on the percentage of heavy trucks and their speed. The higher the percentage of cars and medium trucks (vehicles without a vertical engine exhaust stack) the better the noise reduction.

The basic shape of the frequency spectrum before and after the grinding is similar with the exception that at or about the 1600 Hz 1/3 octave band there is more pronounced reduction in sound pressure level. At measurement Site A (Figures 2 and 5), and Site C (Figure 3) there is a difference in the range of 3 dB to 7 dB at this frequency for the 2000 post grinding measurements. The 2003 post grinding measurements showed further improvement over the 2003 post grinding level in the frequencies above 1000 Hz, in the range of 1 to 4 dB. The pure tone characteristics of the tire noise have been reduced by the pavement grinding. Subjectively, this would contribute to the perception that the post-ground tire noise is lower in noise level than the A-scale difference of 1 to 2 dBA would indicate.

Since the pavement grinding did remove the uniformly spaced transverse tines from the concrete pavement, the high frequency pure tone noise, commonly known as tire whine, has been significantly reduced. Studies conducted in Minnesota, North Dakota and Wisconsin have found that uniformly spaced transverse tined concrete pavement results in the most irritating tire/pavement noise when compared to other transverse or longitudinal tine concrete pavement textures.

The expected reduction of removing the uniformly spaced transverse tined pavement texture would be approximately 3 dB to 5 dB at the pure tone frequencies that generate the tire whine noise. At closer distances to the travel lanes reductions in these same frequencies may be as much as 7 dB.

The use of pavement grinding as a traffic noise abatement measure for I-215 could be beneficial for both reducing tire pavement noise levels and muting the tire whine pure tone sound of the older concrete pavement transverse tining texture.

Figure 1
Noise Measurement Locations

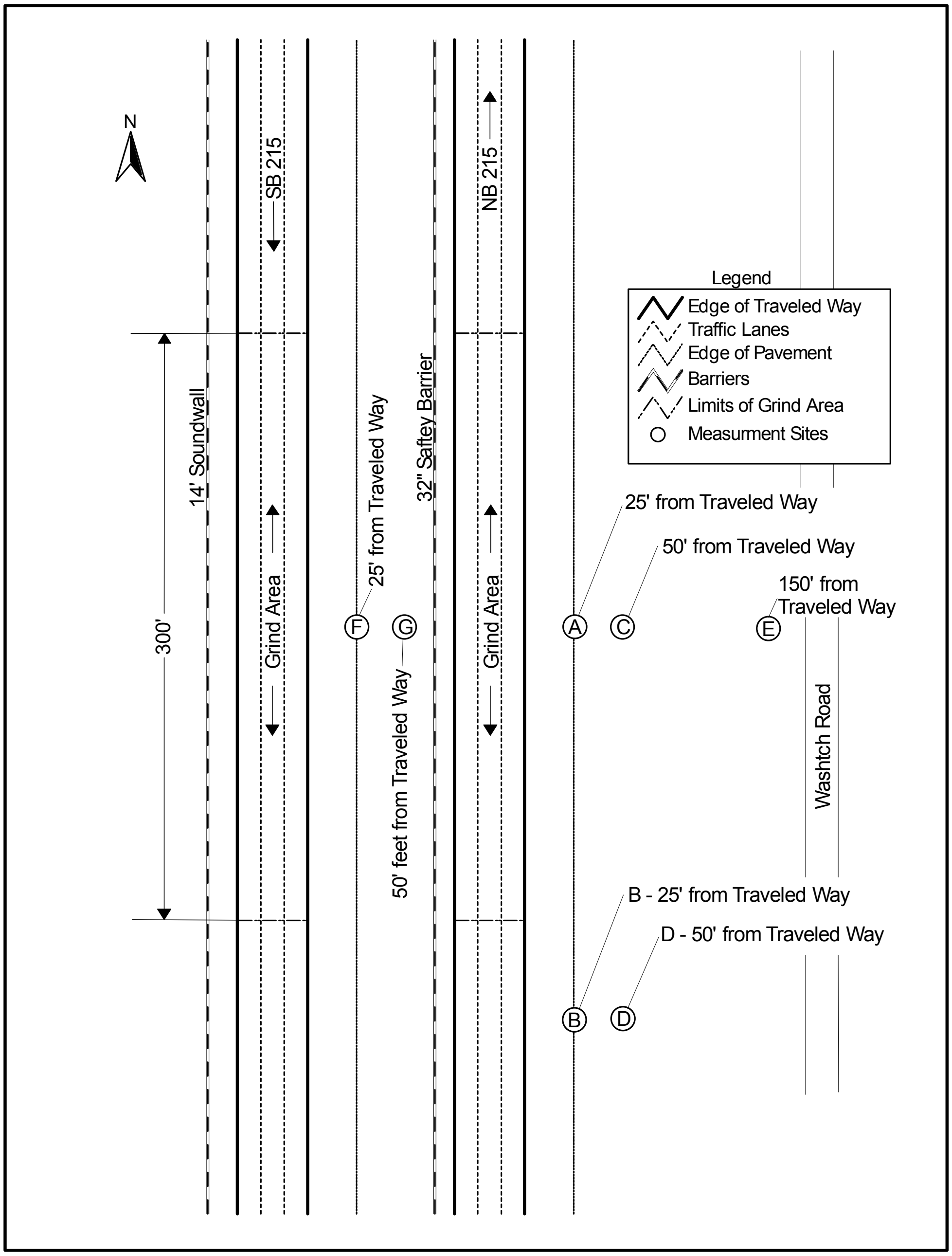


Figure 2 - Comparison of Roadway Grinding at Edge of Shoulder
Measurement Site A

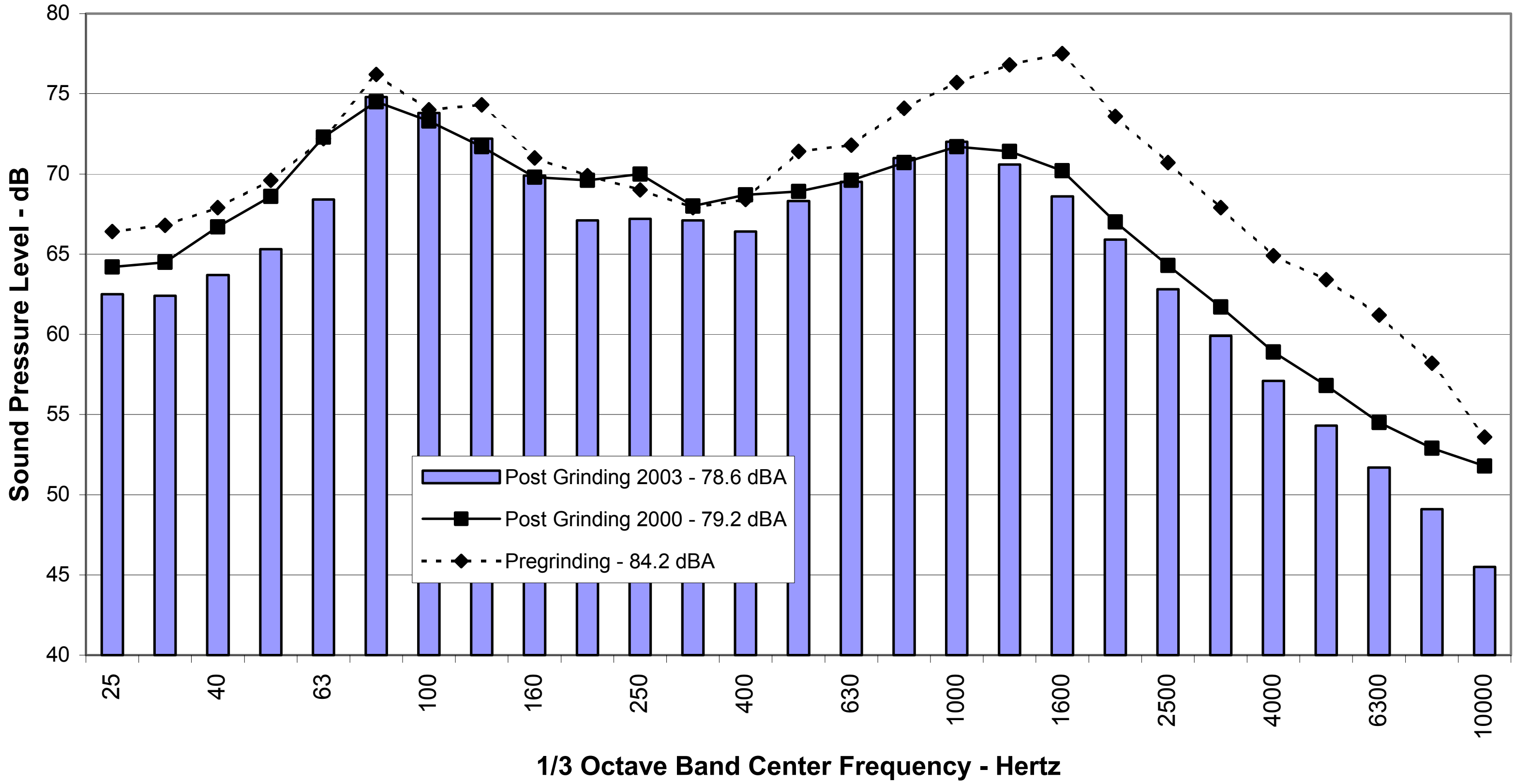


Figure 3 - Comparison of Roadway Grinding at 25 feet from Edge of Shoulder
Measurement Site C

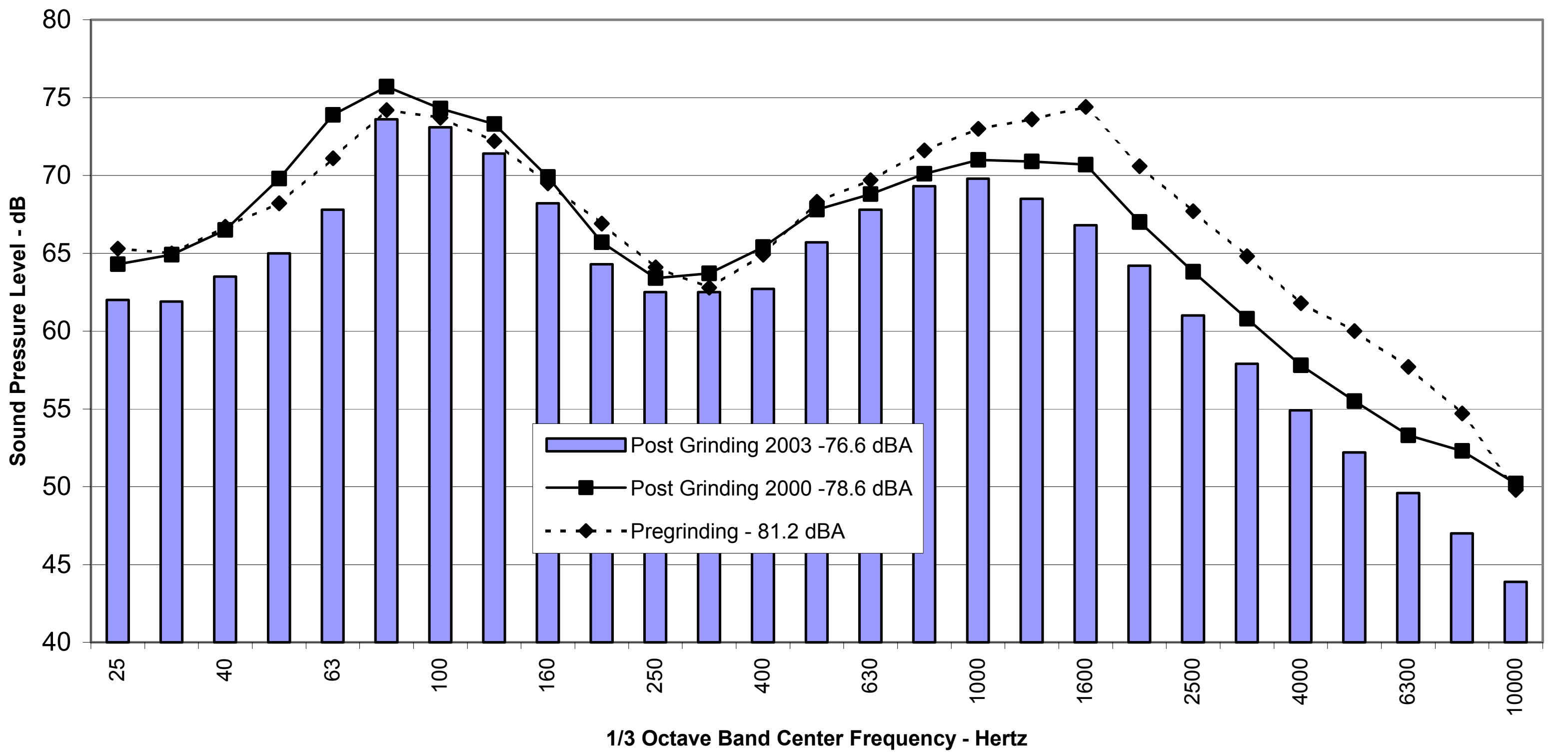


Figure 4 - Comparison of Roadway Grinding at 125 feet from Edge of Shoulder
Measurement Site E

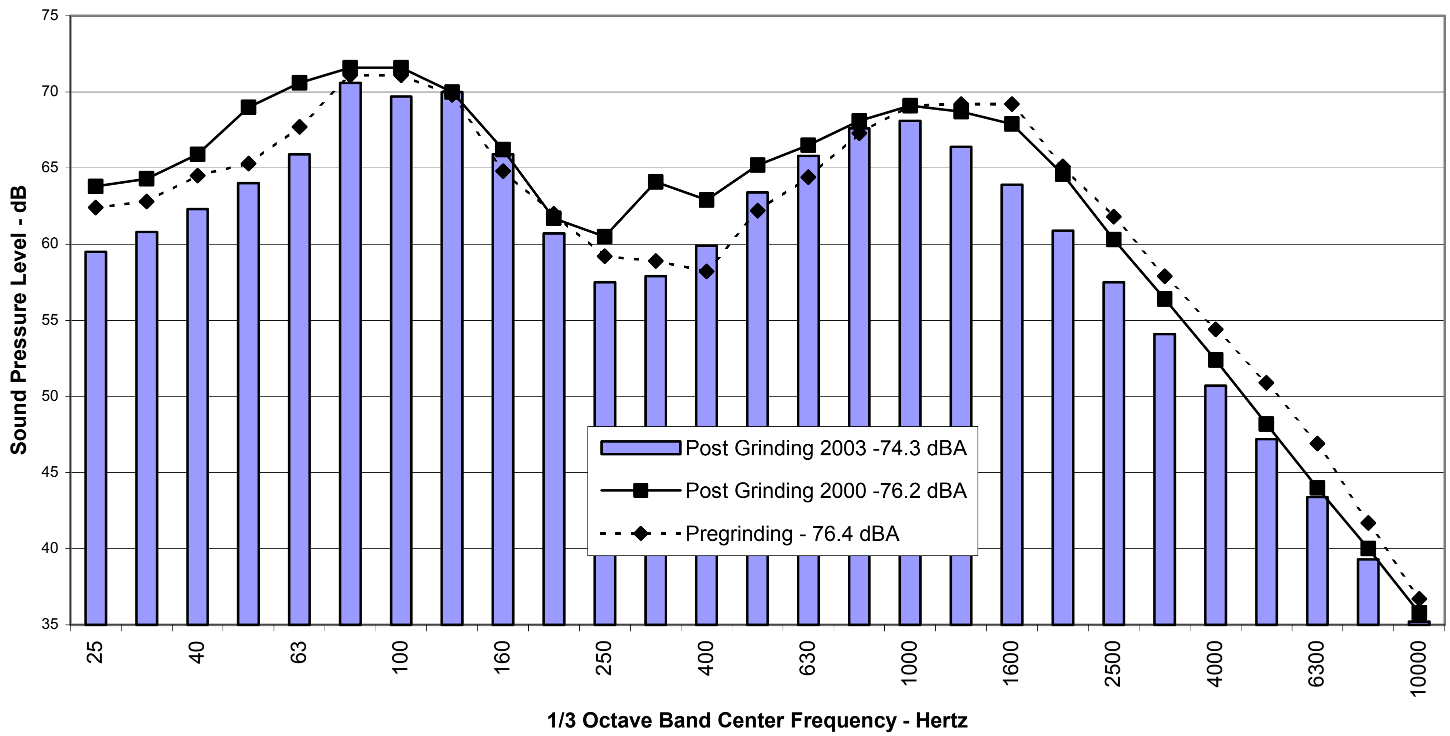


Figure 5 - Comparison of Roadway Grinding at Edge of Shoulder Simultaneous Measurement Site A and B

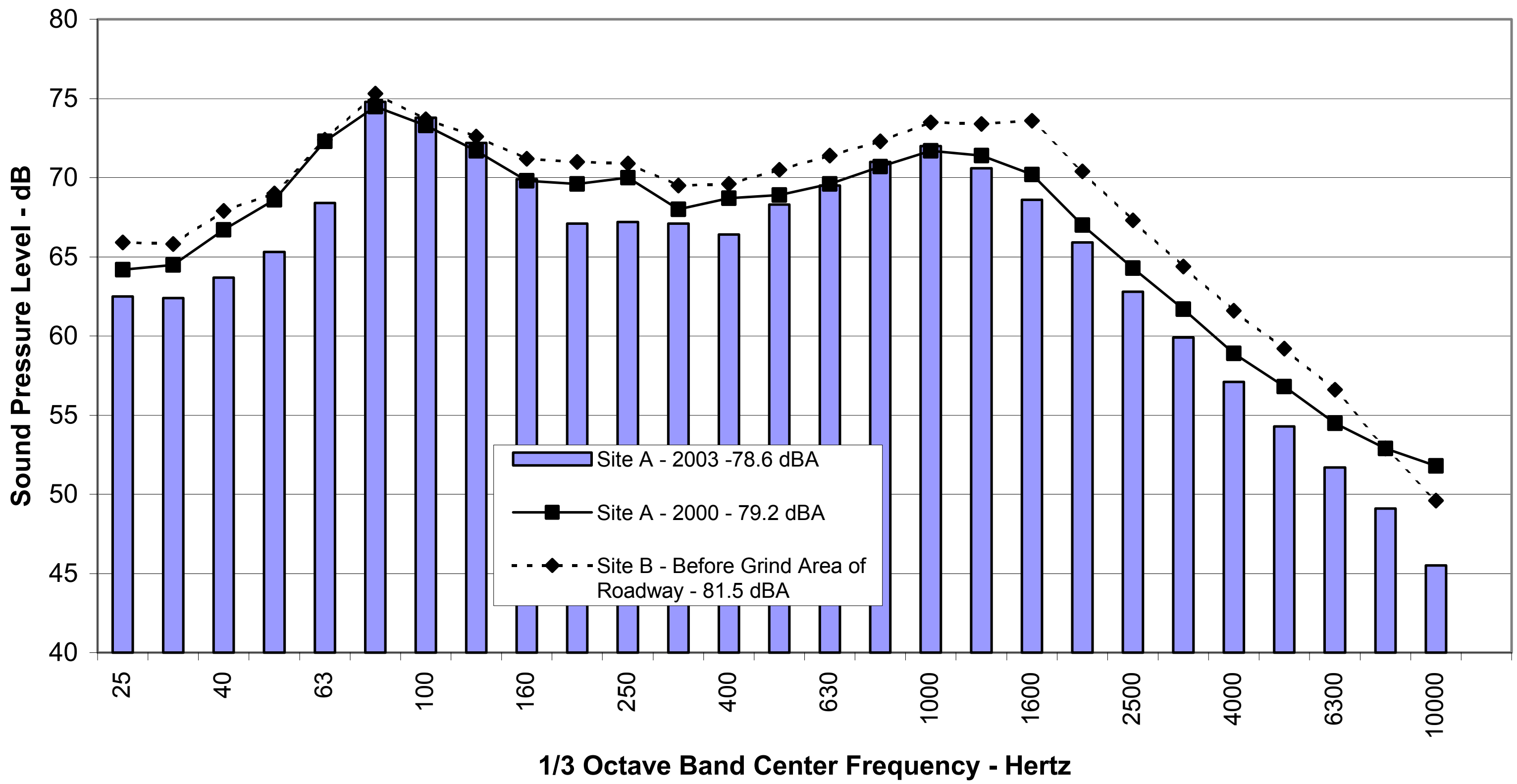
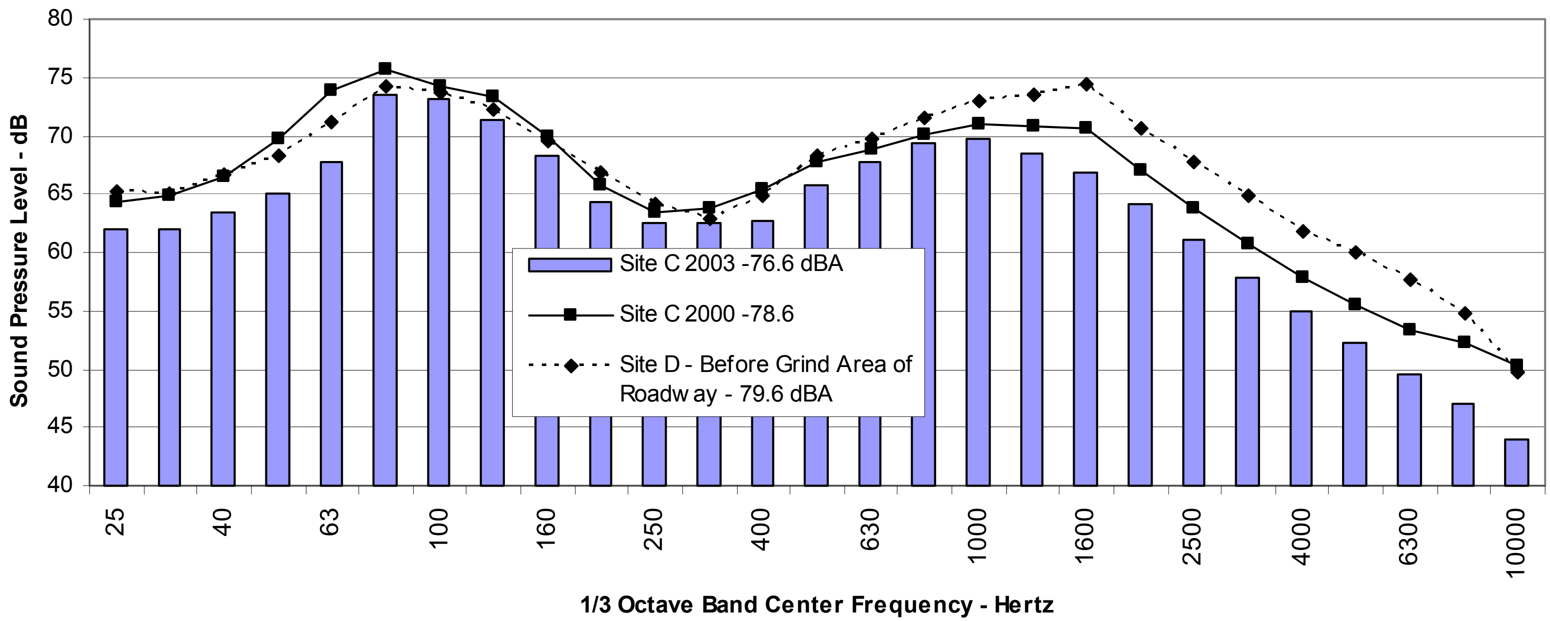


Figure 6 - Comparison of Roadway Grinding at 25 feet from Edge of Shoulder Measurement Site C and D



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